Appendix M. Summary of Water Quality and Quantity Vital-Signs Workshop

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On April 11 and 12, 2003, twenty-three people met in Moab to select proposed water quality and quantity vital signs for the Northern Colorado Plateau Network (NCPN). The purpose of the workshop was to identify high priority waters for monitoring, likely sample sites, parameters to be sampled, suggested sampling schedules and logistical considerations for each of the 16 network parks, which will constitute the draft water quality vital signs. It is recognized that these may be modified as the sampling design proceeds in Phase III.

The summary in this Appendix is primarily limited to the discussions that took place at the workshop. A full presentation of the vital sign selection process was presented in Appendix A and in the body of the Phase II report. Workshop participants are listed in Table C-1 at the end of this Appendix.

APPROACH

As mentioned in the servicewide guidance for development of water quality vital signs (NPS-WRD 2001) there can be several approaches to vital sign selection including a Delphi process (an iterative planning process) and collaborative Internet brainstorming. The Northern Colorado Plateau Network used an approach which meshed perceived management issues as identified by park managers, with preliminary analyses of water quality data undertaken by the U.S. Geological Survey, in addition to the Internet brainstorming effort. Early efforts as part of Phase I focused on the identification of management and scientific issues, which were presented in Appendices O and P in the NCPN Phase I Report (Evenden et al. 2002).

The basis for this approach stems from several sources including Kunkle and colleagues (1987), MacDonald (1991), Davis and colleagues (2001), and online guidance provided by the U.S. Environmental Protection Agency (EPA) at http://www.epa.gov/owow/monitoring/elements/elements.html#6. Some of the materials from these sources that have been useful are included in this Appendix. The EPA website recommends water quality indicators for general designated use categories as shown in Table C-2 at the end of this Appendix. Use category refers to the type of use that a particular water body or stream reach supports. Each state assigns designated use categories and develops quantitative and qualitative standards to protect these uses. In Table C-3, Kunkle and colleagues (1987) suggest another valuable approach, where parameters are linked to specific threats. Differences between protected uses or park management concerns and the type of water source (e.g. large rivers versus springs) is depicted in Table C-4.

The selection of water quality vital signs by the group was a first attempt at identifying parameters that can aid managers in their efforts to recognize water quality and quantity degradation. By working within state water quality standards it should be possible to select a suite of parameters that can lead to quantitative management triggers or thresholds in relation to indicator values. In addition, a park interested in obtaining an Outstanding Natural Resource Water designation for their waters can undertake monitoring with emphasis placed on documenting existing water quality.

Actions Preceding Workshop

The following actions took place prior to the workshop, provided a basis for the discussions that occurred, and made it possible to select draft vital signs for the 16 NCPN park units in a very limited 2-day workshop:

- Developed a servicewide Program Guidance draft document (NPS Water Resources Division),
- Developed a Baseline Water Quality Inventory and Analysis horizon draft document (NPS Water Resources Division, a compilation of data in the STORET database, and limited analysis),
- Analyzed and distributed a questionnaire soliciting input from park staff regarding their significant waters and water quality issues (Colorado State University).
- Conducted park visits to discuss water quality concerns and review available literature (Colorado State University),
- Established contacts with managers of adjacent lands and state water quality agencies (Colorado State University),
- Identified all waters in NCPN parks that are included on the state's 303d lists of waters not meeting standards (Colorado State University),
- Conducted a scoping workshop for NCPN parks in June 2002 that established priorities and goals for water quality monitoring (NCPN),
- Identified water quality issues in each park (NCPN, see Appendices O and P in the NCPN Phase I report),
- Included water quality vital signs in the Delphi process used to develop broader natural resource vital signs (NCPN),
- Assembled available data from STORET, legacy STORET and NWIS, and developed a relational water-quality database conducive to analysis (U.S. Geological Survey, Water Resources Discipline; USGS-WRD),
- Conducted preliminary analyses of data for areas of concern and exceedances of state standards (USGS-WRD); (This was done both prior to the workshop and with real-time data analysis during the workshop),
- Conducted a Water Quality Vital Signs Workshop in April 2003, and
- Provided Workshop participants with numeric and graphical data summaries for each park.

Vital Signs Selection in Relation to Park, Network and Servicewide Goals

In a NCPN water quality workshop held in June 2003, participants agreed that legal mandates, e.g. the Clean Water Act, were the most important to address in the selection of vital signs and a monitoring effort. There was also interest in focusing on long-term monitoring needs as opposed to short-term management needs. The group agreed that the overall NCPN network goals for water-quality and quantity are:

1. Collect, analyze and interpret data to support management in relation to 303(d) listings of waters,
2. Collect, analyze and interpret data to support management of threatened or otherwise special waters, using state standards developed under the Clean Water Act, and
3. Identify data needs, including inventory requirements, in relation to the status and trends of selected indicators for the condition of park ecosystems. These data can provide early warning signs to provide resource managers with the ability to mitigate problems and improve park resources.

Consistent with NPS-WRD recommendations, these goals are ordered to acknowledge that legal mandates are clearly the first priority.

WORKSHOP DISCUSSION

Northern Colorado Plateau Network Perspective

Paul von Guerard, UGSG Grand Junction, presented several general water quality and quantity issues from a network perspective and based on management issues presented by the parks. These include: 1) human contact, 2) recreational impacts, 3) effects of pending and ongoing development adjacent and internal to parks, 4) livestock grazing, 5) threatened and endangered fish and other aquatic species, 6) in-stream water quality standards determined under the Clean Water Act, and 7) land use effects on adjacent federal or state land. He offered Table C-3 (from Kunkle et al. 1987) which depicts key parameters that may respond to each category of impact.

Another means of assessing the parks at a network level derives from the types of water sources within the parks. Two major categories are surface waters and ground waters. Within surface waters, the NCPN parks have examples of perennial, intermittent and ephemeral (e.g. tinajas) water sources. The parks also support groundwater discharges, such as seeps, hanging gardens and springs, which may be included as surface waters. Table C-4, also offered by Paul von Guerard, depicts a matrix of the association between parks, their hydrological characteristics and water quality and quantity issues.

Of major concern to several parks is adjacent land development with increased water consumption and wastewater discharge. Mining of groundwater outside park boundaries may reduce water yield from springs, seeps and wells that support park drinking water sources and wildlife habitat.

Water-Quality and Quantity Issues of Special Interest to Several NCPN Parks

Selenium is a contaminant throughout much of the Colorado River basin with elevated levels due to irrigation practices and development (Butler and Lieb, 2002). Natural background levels are high and associated with particular soil types and geological features such as Mancos shale. Discussions in the workshop concluded that monitoring of selenium would be adequately addressed by (1) including selenium in trace element analysis for the Colorado River and major tributaries, and (2) further studies by the USGS and others agencies.

Pesticides can also be problematic along major rivers in some of the network parks such as Dinosaur NM and Canyonlands NP. While valid, this concern will have to be addressed outside of the NCPN monitoring program due to the very high cost of laboratory analysis for pesticides. Special studies for these parameters may be warranted.

Common water features in NCPN parks are springs, seeps, and tinajas. These sources of water are critical to flora and fauna, and aesthetically important to park visitors and staff. Monitoring is sometimes difficult because the individual water sources, though often diminutive, can be numerous and can have diffuse points of discharge that are difficult to sample. A network approach applicable to many springs is to rotate sampling from year-to-year among several springs, as is currently done in the Southeast Utah Group of parks. In addition, a NCPN effort to specifically inventory and monitor seeps and springs is planned and will be prefaced by a design of a program for the network. Though this will have a broader focus than just water quality and quantity, it will also include an attempt to measure flow, and will likely include site visits that present an opportunity to collect water quality samples.

Existing Monitoring

Two groups of parks have established monitoring efforts, the Southeast Utah Group of parks and a joint effort in Black Canyon of the Gunnison NP and Curecanti NRA. The Southeast Utah Group has been monitoring its water quality and quantity since the early 1990s. Black Canyon of the Gunnison NP/Curecanti NRA is monitoring their waters in an effort to attain anti-degradation and Outstanding National Resource Water status for approximately 21 water sources. These existing monitoring programs provide examples that can be applied to other parks.

Relating Vitals Signs Selection to Ecological Models

Several parks including Black Canyon of the Gunnison NP, Curecanti NRA, Capitol Reef NP, Canyonlands NP, Dinosaur NM, and Zion NP have large river systems flowing through them. These are major drivers affecting both the physical and biological components of the parks' ecosystems. As noted in the discussion of the ecological model for riverine systems in the Phase I report, understanding the importance of the spatial and temporal scale leads to development of a monitoring program which may detect system degradation over the long-term via measurement of sediment transport and channel morphometry. Monitoring for the long-term was of particular interest to the June 2002 workshop participants. However, a more immediate concern is capturing water quality characteristics that can change rapidly (e.g. minutes, hours or daily fluctuations) such as streamflow, temperature, pH, dissolved oxygen and specific conductance. Several years of data, and/or data collected at frequent intervals, are needed to reveal trends that relate to system degradation. Since measuring sediment transport is expensive and difficult, biological monitoring may serve as a link between monitoring water quality and trying to determine if the system has degraded to a point that the major ecosystem drivers have changed. Figure C-1 (from Davis et al. 2001) integrates aspects of river ecosystems, emphasizing the importance of the biological component.

Core Vital Signs

The NPS Water Resources Division has added flow to the original core vitals signs for water quality (pH, temperature, specific conductance, and dissolved oxygen). The participants concurred with this decision, citing the intimate relationship between flow and the concentration of many dissolved constituents, between flow and sediment transport, and the need to consider flow in effective data analysis. If flow could not be measured quantitatively, then, at a minimum, a qualitative measurement such as low, medium, or high would be assigned. Several workshop participants mentioned the importance of water quantity from its potential as floods flowing in small canyons in Colorado NM, to its ability to carry sediments in the Green, Yampa, Colorado, and Fremont rivers.

Park-by-Park Selection of Vital Signs and Sites

The participants proceeded with a park-by-park selection of vital signs. The following is a summary of the discussions that took place. Matrices depicting water sources, vital signs, schedules, priorities and logistical considerations were developed for each park. These can be found in the body of the NCPN Phase II report, so are not included in this Appendix. For ease of use, park discussions are presented below in alphabetical order rather than in the chronological order as they occurred during the workshop.

<u>Arches National Park, Canyonlands National Park, Hovenweep National Monument, and National Bridges National Monument (Southeast Utah Group)</u>

Charlie Schelz provided an overview of water resources and threats to the four parks. Cooperative monitoring with the Utah DEQ currently occurs. The park samples monthly at several sites (typically three) and rotates through sites each year over a 3-year period. The park program costs from $5000 to $10,000 per year. Utah DEQ’s contribution is the analysis of samples and data entry. Analysis costs $350/sample.

Paul von Guerard wondered if there is a concern whether the current QA/QC documentation is sufficient to meet legal scrutiny, as QA/QC data scrutiny is becoming a major issue. Pete noted that QA/QC is addressed in the NPS-WRD guidance for WQ monitoring. The Phase III report will address water quality design work and will have to include QA/QC protocols.

At Arches NP, Courthouse Wash, Freshwater Spring, Sleepy Hollow (the pool), Willow Spring, and Salt Wash are currently monitored for core parameters, flow, nutrients, major ions, trace elements, total suspended solids and dissolved solids 12 times/year. Sites are rotated annually such that 3 sites per year are monitored. Macroinvertebrates are monitored on a quarterly basis, and microorganisms on a monthly basis in-house.

At Hovenweep NM, the park monitors Little Ruin, Hackberry and Cahon springs. At Natural Bridges NM, the park monitors Tuwa, White and Armstrong springs. The same suites of parameters that are measured at Arches NP are also measured at Hovenweep NM and Natural Bridges NM. At Canyonlands NP, the Green and Colorado Rivers are monitored from April through October on a monthly basis. The Utah DEQ appreciates this effort since accessibility is difficult. The park monitors core parameters, flow, nutrients, trace elements, major ions, total suspended solids, dissolved solids and turbidity. They would also like to monitor pesticides. Also in Canyonlands NP, Cave Spring, Little Spring Canyon, 2.4 Mile Loop, Bates-Wilson, Crescent Arch, Peekaboo, and the Maze Overlook are monitored for the same parameters as springs in Arches NP. The SEUG would like to continue with this monitoring effort that they began in the late 1980s, and would like support for the program. SEUG considers all of their sites high priority, with the rotating scheme working well.

<u>Bryce Canyon National Monument</u>

Sharrow provided a description of park geology and hydrology. The park and its developed areas sit atop the rim of the Paunsaugunt Plateau. Many of the springs are downslope from this.

Kelly Cahill provided an overview of park issues and noted that the Tropic ditch, a privately owned water conveyance that flows through the park, serves as a vector for weed introduction. This unlined ditch provides a major source of irrigation water for farmers in Tropic, and could possibly be recharging springs in that area of the park. Other issues for the park include livestock trailing through meadows and potential development on BLM land south of park managed by Kanab Field Office. The potential issue associated with coal bed methane is the discharge of large amounts of wastewater that might potentially contaminate the Navajo sandstone aquifer. The park is concerned, since it may eventually need to drill into the Navajo to acquire water for park uses. Wastewater disposal within the park occurs on the rim and could potentially impact spring water quality; however the infrastructure has been newly lined and working well.

Incidence of chitrid fungus on amphibians occurs in the Dixie NF below Bryce Canyon NP. Kevin Alexander noted that there is probably not a water quality link associated with this fungus.

The group agreed that Yellow and Sheep creeks were a high priority and could be monitored cooperatively. Core parameters, flow, nutrients, major ions, total dissolved solids, turbidity, and macroinvertebrates would be measured. Other springs (Cope, Water Canyon, Campbell, Right Fork, Iron, Lonely and Riggs springs) below the rim were considered as high priority with the same parameters measured as for the creeks. The group agreed that the Podunk Creek wetland was of medium priority and could be rotated with the other springs. Dave's Hollow was low priority since the park could rely on water supply monitoring at this site.

Capitol Reef National Park

Tom Clark presented a synopsis of the park waters and issues. He noted a need for baseline data for the park's tinajas, a very important water feature for the park. This effort could be a part of the entire spring/seep inventory being contemplated by the network.

The Fremont River is on the 303(d) list. Although the river is viewed as one segment from its headwaters to the eastern boundary of the park for state water quality standards, the 303(d) listing separates it into 2 segments for water quality limitations. From Bicknell (which is west of the park) to its headwaters, the Fremont is listed as not meeting standards for dissolved oxygen and total phosphorus. From its confluence with Muddy Creek to the park's eastern boundary, the Fremont River is listed for total dissolved solids. In essence, the Fremont River within the park is not on the 303(d) list, though total phosphorus levels at Hickman Bridge (within the park) have exceeded the state guidelines for total phosphorus on several occasions. The TMDL is complete for the river and various best management practices, such as removal of a corral adjacent to the river, are being applied. Tom Clark suggested waiting to see if these practices improve the turbidity and total phosphorus levels within the park.

The park would like to monitor the Fremont River, and the perennial Sulphur, Pleasant, Oak, and Halls creeks. They would also like to monitor the intermittent Deep, Polk and Bulberry creeks. The highest priority would be given to the perennial creeks, while the state would continue to monitor the Fremont River. The park would cooperatively sample the other creeks. A suite of information would be monitored including core parameters, flow, nutrients, trace elements, and major ions, total suspended solids and dissolved solids. Due to access difficulty, Capitol Reef NP could perhaps coordinate with GLCA or another park to sample Halls Creek. Deep, Polk and Bulberry creeks, and Middle Desert Wash received medium priority with measuring of core parameters, flow, and macroinvertebrates.

Cedar Breaks National Monument

Sharrow provided an overview of park geology, water resources, and issues. Water quality issues are minor at Cedar Breaks NM, since park development does not impact springs. The park is situated in a high elevation position on the Colorado Plateau at the watershed divide between the Sevier River to the east and Coal Creek to the west. It could serve as a useful baseline measurement site for springs representative of the general geologic area. The issues that are most important include the park's wastewater treatment system, trespass cattle grazing and grazing near springs, particularly the spring that supports the Arizona willow (*Salix arizonica*). Pesticide use to control beetles on adjacent National Forest lands is another concern.

Cedar Breaks has springs within the breaks (the very rugged area of the park below the rim) and a few on the rim. Blowhard Spring is the drinking water source for the park and is monitored by the park. Sampling Alpine Pond, and the springs on the rim is a low priority and could be easily rotated in a 2-year program with Zion NP. The springs located in the breaks are of medium priority and could be part of the network spring and seep inventory with a comprehensive water quality analysis including core parameters, flow, nutrients, major ions, trace elements, total suspended solids and dissolved solids. Routine monitoring of springs in the breaks would present significant logistical problems.

<u>Colorado National Monument</u>

The monument lies on the northeastern edge of the Uncompahgre Plateau where it abruptly terminates and joins the Grand Valley. The park encompasses geologic features consisting of very steep drainages cutting through shales and sandstones of the Jurassic age. The Wingate Formation is the most visible geologic layer. Above the park is the Glade Park area, where development of 35-acre and smaller tracts occurs. The major issue at Colorado NM is water quantity. Water can flow through steep canyons downstream into an area where houses have been built at the mouth of the canyons on alluvial fans and in floodplains. A flood in No Thoroughfare Canyon was estimated by park staff to be 9000 cfs. Water in canyons from springs does not ordinarily reach the Colorado River, though flow from storm events can easily reach the mouths of the canyons and any dwellings in their floodplain.

A synoptic water quality study was conducted by USGS for all of the drainages within the park. Selenium levels in some drainages were above state standards; however, this most likely is a result of natural background levels. More importantly, the park could measure flows in canyons that would be covered under the inventory and monitoring effort. Water quantity measurements are a particularly high priority in No Thoroughfare Canyon, Monument Canyon, Fruita Canyon, and Red Canyon. These sites would be monitored once per month and also during spring runoff and during large precipitation events.

<u>Curecanti National Recreation Area and Black Canyon of the Gunnison River National Park</u>

Matt Malick provided an overview of the parks and their water issues. Threat of future water degradation is primarily from housing/urban/resort development in canyons and along drainages.

Curecanti NRA/Black Canyon of the Gunnison NP changed their water quality monitoring program a couple of years ago to begin intensive sampling aimed at attaining

Outstanding National Resource Water (ONRW) status for some of their waters. Malick and his crew sample 21 sites in both parks. Almost all sites reveal good water quality adequate for anti-degradation designation, but it is currently, and will continue to be, a political issue. Most anti-degradation designations in the State of Colorado are on wilderness streams, which are at high-elevations in upper basins where no upstream uses could be impacted by such a designation. Anti-degradation standards are specific to particular parameters. If the designation were attained, the park would probably require compliance sampling at least quarterly. Current sampling is 7 times per year.

Funding to support data acquisition in support of anti-degradation designation runs through the end of 2004, but the park needs data through 2006 to build the required data record for the state rulemaking.

The parks would like to begin monitoring volatile organic carbon (VOCs) to assess the contamination of reservoir waters by fuels from motorboats and other motorized water craft, thought it was noted that VOCs are very expensive to monitor. Synoptic sampling efforts are almost prohibitively expensive.

Sharrow questioned Malick about his concern with the susceptibility of Curecanti NRA/Black Canyon of the Gunnison NP waters to effects of atmospheric deposition due to low ANC / alkalinity (acid), or atmospheric deposition of toxics / metals (e.g., mercury). As this time, there does not appear to be a concern. Kirby Wynn noted that the USGS has an atmospheric deposition network in the Rocky Mountains and throughout the west in cooperation with the NPS and other agencies. To detect mercury deposition, one has to sample the snow pack, which is very difficult to adequately do. Another method is to sample fish tissues. Kirby Wynn will work with Dave Sharrow and the NCPN to discuss data sources /issues regarding atmospheric deposition.

Consensus among the group was that the way to address monitoring for atmospheric deposition of metals, particularly mercury, was to use direct atmospheric deposition monitoring (e.g., NADP) rather than to monitor surface water chemistry. This discussion pertained to vital signs discussions earlier in the week. The surface water chemistry related to an atmospheric deposition vital sign was dropped and relegated to the water quality workshop discussions.

Malick had concern with potential high total P values in tributaries. Paul von Guerard suggested that this might be originating from volcanic geology. The USGS real-time display of data indicated that high total P is very common in the Curecanti NRA region.

The park's current sampling scheme was noted and documented in the accompanying matrix. The park samples the Gunnison, the Lake Fork of the Gunnison, and Cimarron rivers, and major tributaries and reservoirs for an array of parameters. They work with the USGS to accomplish the task.

Dinosaur National Monument

Tamara Naumann provided an orientation to Dinosaur NM and noted that it spans two states and serves as grazing land for approximately 2,300 AUMs of livestock with 11 separate allotments. The park is responsible for permitting livestock, yet has relatively no staff to administer the permits. The Green and Yampa rivers comprise the largest and most significant water sources in the park. Both Vermillion and Red creeks are significant tributaries to the Green River. These creeks contribute a substantial sediment load to the Green River, helping to recover the natural load lost as a result of Flaming Gorge Reservoir.

Naumann noted that her main concern with the Yampa is that it is the last major unregulated tributary in Colorado River system and stressed that the park needs good baseline monitoring for purposes of comparisons with regulated rivers. While there are diversions and depletions on the Yampa River, there are no big dams that prevent natural spring peak flows or summer low flows. Naumann suggested that the Yampa River should be considered as a reference area for the upper Green River, which is a regulated system.

Naumann wanted to add Cub Creek and Jones Hole Creek, the site of a fish hatchery, to the discussion matrix for consideration for monitoring. The discharge from the hatchery is sampled as part of the National Pollutant Discharge Elimination System (NPDES) program, but the park would like to take in stream samples as well.

Norm Henderson questioned if an NPS goal was to establish anti-degradation standards for the Yampa River. At the present time, it was not clear, though several participants noted that river rafters take precautions regarding infections from cuts and abrasions exposed to Yampa River water. As such, understanding supposed contamination of water by pathogens and its general quality might precede establishing anti-degradation standards.

Naumann wanted to ensure that Mark Vinson's macroinvertebrate data are in the USGS-NCPN database. One of the park issues is the appearance of the exotic New Zealand mud snail now in Green River below Flaming Gorge dam.

Some parameters are captured by other monitoring programs such as the U.S. Fish & Wildlife's efforts with temperature and pH at various sites on the Green and Yampa rivers (1987 – present, see http://www.r6.fws.gov/riverdata/.) Salinity was monitored on the Yampa River but was stopped due to a lack of data analysis. Paul von Guerard discussed questions associated with pH values in the Yampa River noting that recent analysis indicated that previously reported upward trends in pH may be attributable to poor methods and instruments through the mid-1980s (see Chafin 2002).

Naumann wanted to ensure that the spring/seep inventory design included input from water quality experts. Two water quality studies of the approximately 90 springs in the park have been completed (Rice 1998, Foster et al. 2000).

During a real-time data analysis by the USGS, Cudlip expressed concern with the total phosphorus data for the Green River in Dinosaur NM. Von Guerard suggested that total phosphorus should be plotted against TDS or TSS, which would reveal if the total phosphorus were associated with particulate matter. Richard Denton said the DEQ has not placed the Green River on the 303(d) list for total P, since it was fairly clear that the total P comes from the Yampa River, which is a state of Colorado problem. Colorado does not have a guideline or standard for total P.

The group agreed that the Green River would be monitored at the Gates of Lodore, and at the Jensen site where it is currently being sampled by the state of Utah. The Yampa River would be monitored at Deer Lodge. All of these are high priority sites. Parameters of interest included the suite that the Utah DEQ can collect and analyze, turbidity, total suspended solids, dissolved solids, and macroinvertebrates. Pesticides would be measured on the Yampa River since intense agricultural use occurs upstream. Of medium priority are Cub and Jones Hole creeks. The upland sites were considered low priority and should be studied as part of the network spring/seep inventory effort.

Fossil Butte National Monument

Clay Kyte would like to see watershed and sediment yield monitoring on Chicken Creek where flow is channeled into a culvert at the southern park boundary. The park has questions and issues related to previous livestock and railroad impacts. Von Guerard and Sharrow stated that the use of geomorphic indicators and aerial photos may be the best approach to look at watershed changes over time. The BLM wants to conduct a controlled burn on west side of the park using a park road within the park as a firebreak. Livestock were excluded from the park following the growing season of 1989. Fossil Butte NM supports one of the few ungrazed sagebrush systems in the region.

Kyte explained that the spring and seep zone occurs at the contact between the relatively coarse Green River Formation and the fine-textured Wasatch Formation. The springs feed approximately 20 ponds dammed by beavers, though most of these are currently dry due to drought. Kyte asked whether atmospheric deposition would manifest in springs since drawdown of recharge in the Green River Formation appears to be relatively rapid, within 2-3 years. The park also has a concern over the potential demand to develop water and pipe it outside of the park to support livestock.

The group suggested that the use of aerial photos and the park cross-section data would allow an evaluation of the Chicken Creek restoration efforts. The group also suggested looking at the plant community as a measure of recovery. Measurement of quantity would also be helpful.

Kyte noted that the NPS Horizon report for Fossil Butte NM did not adequately characterize the springs coming out of Green River Formation. The group decided that Cundick Spring, East and West Small Pox Springs, and the Green River Formation Springs were of medium priority and could be monitored 4 times per year. This effort would be coordinated with the overall network spring inventory. Chicken Creek was also of medium priority and would be monitored 4 times per year. However, the group thought that water quality assessment should be aligned with the aquatic and wetland and geomorphic indicator assessment.

Golden Spike National Historic Site

Dave Sharrow noted that park management considers it a low priority to monitor Blue Creek.

Richard Denton, with the Utah DEQ, has a site on Blue Creek below the Thiokol plant, which is within 200-300 yards of Golden Spike NHS. The USGS confirmed that data are in the NCPM-USGS database, though this single physical site has four different site IDs. The group concurred that Golden Spike NHS is covered sufficiently by the DEQ Blue Creek sampling. Blue Creek is characterized so that the state can discern what Thiokol is contributing to stream. At this time, Utah DEQ has not observed water quality problems on Blue Creek. Utah DEQ will work with NCPN/USGS to clarify the site IDs on Blue Creek. In general, each park should work with Utah DEQ to determine which sites contain possible multiple site names.

Pipe Spring National Monument

Issues are entirely water quantity related at Pipe Spring NM. Sharrow described the hydrogeology of the springs at the monument. Flow monitoring since the 1930's documents permanent flow from four springs. West Cabin Spring (mostly a seep) generally flowed from ½ to 2 gpm, Tunnel Spring (established in 1906 by digging a horizontal tunnel into the hillside) from 5 to 15 gpm, Main Spring from 5 to 30 gpm, and Spring Room Spring from 1-6 gpm. Flows from Main Spring and Spring Room Spring gradually diminished over the latter 1970's through the 1990's, while Tunnel Spring showed a slight increase in flow – suggesting that new fractures opened permitting water to flow by gravity to Tunnel Spring which is 20 feet lower in elevation.

In June, 1999, Main Spring and Spring Room Spring ceased to flow. To keep what water they had, and aware that the adit for Tunnel Spring was in poor condition, the monument attempted to stabilize the structure. A concrete tunnel was installed in an excavated trench to support the front ½ of the tunnel, but as stabilization proceeded deeper into the tunnel it collapsed completely. Discharge from Tunnel Spring was maintained by forcing culverts through the breakdown. It now discharges about 10 gpm. Water is now piped from Tunnel Spring to the Spring Room and ponds. Discharges from West Cabin Spring remain unchanged or have increased slightly during this period. It remains the only free flowing spring in the monument.

Water is pumped off site to meet a 1933 agreement to provide water for livestock growers and the Kaibab Paiute Indian reservation. The water is distributed as follows: 1/3 to NPS, 1/3 to the Kaibab Band of Paiute Indians, and 1/3 to the livestock users association. The park uses the tribal portion in exchange for potable water from the NPS well.

Since 1976, the NPS has observed a decline of about 50 percent in the combined discharge from springs at the monument, with an average decrease of about 2 (gal/min)/yr (Truini, 1999; Barrett and Williams, 1986). After discharge from Spring Room and Main Springs ceased in June 1999, Sharrow (1999) tested the addition and removal of water from Main Spring and Spring Room Spring, demonstrating that these features are hydrologically connected in the subsurface.

The group agreed that monitoring should occur at Tunnel Spring and West Cabin Spring. Water quality would be measured including core parameters, stream flow and major ions. The latter would be measured to continue to establish whether the springs are hydrologically connected. The monument recognizes that there could be serious water quality issues with these springs, though they are not used for drinking water. The monument supply is well upstream and may impact flow. The group suggested monitoring of springs on a quarterly basis as a medium priority. The group concurred that if the State of Utah lab were used, a suite parameters would be measured including nutrients and metals.

Timpanogos Cave National Monument

A fish advisory exists on the North Fork of the American Fork River. Recreational fishing does occur in the park. The advisory, from the Utah DEQ and the Utah Dept. of Health, notes that as a result of elevated arsenic levels in the fish meat, adults should limit their consumption of brown and cutthroat trout to no more than one meal per month. Pregnant women, nursing mothers and children under the age of 12 should avoid eating any trout from the creek (Utah DEQ, May 21, 2002 release on website, http://www.deq.state.ut.us/offices/ppa/news/PRESSRLS/2002/052102.htm). Because the Forest Service extensively monitors the American Fork River, a NPS effort would be of low priority.

The monument supports 3 major cave ponds and approximately 30 other pools. The greatest concerns are the cave waters. The monument received money to monitor caves for next 2 years (NPS-WRD project funding). Major ions and trace elements are of most interest. The group suggested waiting until the completion of this study to determine what will continue to be monitored.

There is a pit privy on the trail up to caves. A concern is that a potential source of contamination occurs from the privy to springs downstream. The park could fix the privy system, alleviating the need to monitor springs, however, the group conceded that monitoring for human waste or caffeine combined with the core parameters would be desirable if monitoring is to be performed.

Zion National Park

Dave Sharrow began the discussion by describing the park's waters, watershed land uses (agriculture/grazing, housing development, roads), and visitation patterns as they pertain to water resources. The main drainages include the East Fork of the Virgin River and the

North Fork of the Virgin River. Other important perennial tributaries include North, La Verkin, Deep, Kolob, and Pine Creeks. Extremely important features of Zion NP are its hanging gardens and springs.

North Creek is on 303d list for total dissolved solids (TDS), however, the data is currently under state review. In addition, the source of the TDS is almost certainly natural discharge from springs in the park, so corrective action would not be desirable from the park's perspective.

Ninety percent of the stream flow in Zion NP is from groundwater discharge associated with the contact between the Navajo sandstone and the Kayenta formation. High visitor use occurs in the North Fork of Virgin River in the Narrows section where some 2000 visitors hike the canyon per day. Coal bed methane leases exist in North Fork drainage, but no development has occurred yet. Data review show high bacteria (fecal-coliform) results in North Fork of Virgin, probably attributable to upstream livestock / irrigated pastures on river banks above the park.

Richard Denton with the Utah DEQ noted that the BLM, in a cooperative manner with the State of Utah, is conducting regular sampling above the falls of La Verkin creek, which is 5 miles below Zion NP. As sampling was initiated approximately one year ago, data may not yet be uploaded to STORET and therefore, not captured in the USGS-NCPN database.

Sharrow's concern is that sampling frequency requirements for documenting bacteria exceedence are much higher than frequency requirements for chemistry exceedences. He recommended that bacteria be monitored synoptically to understand the system, rather than as part of a regular monitoring program because the high-frequency requirement would constrain a budget.

Denton recommended sending the macroinvertebrate samples to the Bug Lab in Logan, UT for analysis, since that is where the Utah DEQ sends their samples. He recommended spring-fall sampling, when most invertebrates are present. Kevin Alexander, Western State College, aquatic invertebrate specialist, concurred.

Charlie Schelz uses portable weirs for estimating discharge at hanging gardens in Arches NP and suggested a similar application for monitoring in Zion NP. Richard Denton was willing to analyze a few synoptic samples from hanging gardens or seeps in order to establish baseline conditions.

Tamara Naumann wondered whether it was premature to begin considering what parameters to monitor at hanging gardens before the NCPN seep/spring/hanging-garden inventory has been conducted, noting that baseline data can inform monitoring decisions. She was optimistic that the inventory would be designed with input from hydrologists who could recommend what hydrologic and water quality parameters should be included in the inventory. Schelz agreed. There was general support for the idea that monitoring of most springs, seeps and hanging gardens at any of the NCPN parks wait until the inventory has been completed.

Pete Penoyer remarked that the water quality-monitoring program is adaptive and can adjust in the future based on new data and/or considerations.

Paul von Guerard noted that caffeine has been used as an indicator of groundwater contamination by wastewater.

Norm Henderson questioned what the NCPN perspective was on the overall focus of vital signs monitoring - to track general trends in resources or to provide focused data for managers? He stated that while data collection is a fine endeavor, would that data be useful in allowing resource managers to find solutions to water quality problems?

Vital signs and potential sites for Zion NP were selected and priorities and schedules were noted (see discussion in body of Phase II report). The North and East Forks of the Virgin River will be monitored for the core parameters, nutrients, trace elements, major ions, macroinvertebrates, total dissolved solids, suspended solids and turbidity. The North Fork will additionally be monitored for microorganisms. The state can cooperate on several sites including the North and East Forks of the Virgin River. They will be working on North Creek as part of the TMDL analysis. The group concurred that Deep and Kolob Creeks were low priorities due to their remote location, and Pine Creek due to its minimal flow.

Other Topics Discussed

<u>Hypothesis Testing</u>

The NPS Inventory and Monitoring Program and the NPCN consider the formulation of monitoring questions as true hypotheses to be desirable. However in contemplating the process used to select vital signs, specific questions or hypotheses were not posed due to time constraints and the existing framework of water quality standards. Instead, management and scientific issues for each park were identified and the existing data analyzed. Specific hypotheses can be derived from both issues discussions and data analysis. For example, one of Arches NP’s management concerns is stated as change in stream flow at springs from development. The question this park is posing becomes, “Development in the form of domestic wells changes flow at the park’s spring.” For Bryce Canyon NP one of the management concerns is the impact of visitor use in drainages and at springs. Translated into a hypothesis to be tested, this becomes, “Visitors impact the water quality of drainages and springs.” More thoroughly, “Visitor activities increase turbidity, sedimentation or fecal coliform levels in the drainages.” And statistically, this could be stated as, “Do 95% of all observations of turbidity fall within historic levels?”

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Table 1. Participants in water quality and quantity vital signs workshop for the Northern Colorado Plateau Network, held April 10-11, 2003 in Moab, Utah.

Participant	Representing
Mark Miller	Northern Colorado Plateau Network
Pete Penoyer	NPS – Water Resources Division, Ft. Collins
Norm Henderson	NPS – Colorado River Coordinator
Anne Brasher	USGS – WRD, Salt Lake City
Kevin Alexander	Western State College
Paul von Guerard	USGS – WRD, Grand Junction
Kelly Cahill	Bryce Canyon National Park
Dave Sharrow	Zion NP, Pipe Spring NM, & Cedar Breaks NM
Elizabeth Nance	Northern Colorado Plateau Network
Aneth Wight	Northern Colorado Plateau Network
Margaret Beer	Northern Colorado Plateau Network
Clay Kyte	Fossil Butte National Monument
Ed Krumpe	University of Idaho, Moscow
Tom Clark	Capitol Reef National Park
Matt Malick	Curecanti National Recreation Area
Lynn Cudlip	Western State College
Charlie Schelz	NPS - Southeast Utah Group
Tamara Naumann	Dinosaur National Monument
Juliane Brown	USGS – WRD, Denver
Sharon Day	USGS – WRD, Denver
Kirby Wynn	USGS – WRD, Grand Junction
Richard Denton	Utah Division of Water Quality
Lisa Thomas	Southern Colorado Plateau Network

Table 2. Recommended water quality indicators for general designated use categories. (EPA; http://www.epa.gov/owow/monitoring/elements/elements.html#6)

	General Designated-Use Categories			
	Aquatic Life & Wildlife	**Recreation**	**Drinking Water**	**Fish/Shellfish Consumption**
Recommended Core Indicators	Condition of biological communities Dissolved oxygen Temperature pH Habitat assessment Flow Nutrients Landscape conditions (e.g. % cover of land uses) Additional indicators for lakes and wetlands: Eutrophic condition, hydrogeomorphic settings and functions	Pathogen indicators (*E.coli, enterococci*) Nuisance plant growth Flow Nutrients Chlorophyll Landscape conditions Additional indicators for lakes and wetlands: Secchi depth, hydrogeomorphic settings and functions	Trace metals Pathogens Nitrates Salinity Sediments/TDS Flow Landscape conditions	Pathogens Mercury Chlordane DDT PCBs Landscape conditions
Supplemental Indicators	Ambient toxicity Sediment toxicity Other chemicals of concern in water column or sediment Health of organisms	Other chemicals of concern in water column or sediment Hazardous chemicals Aesthetics	VOCs (in reservoirs) Hydrophylic pesticides Nutrients Other chemicals of concern in water column or sediment Algae	Other chemicals of concern in water column or sediment

Table 3. Water-quality parameters pertinent to specific resource threats (adapted and updated from Kunkle et al. 1987).

Visitor Use	**Agriculture**	**Residential Development**	**Oil & Gas, Mining**
BOD Chloride Chlorine COD DO Flow Hardness Macroinvertebrates Microorganisms Nutrients Oil & Grease pH Specific conductance Settleable solids Surfactants Temperature Trace elements (metals) Turbidity	BOD Chloride COD DO Flow Macroinvertebrates Microorganisms Nutrients pH Specific conductance Temperature Total dissolved solids Total suspended solids Turbidity	BOD Chloride Chlorine COD DO Flow Hardness Macroinvertebrates Microorganisms Nutrients Oil & Grease pH Settleable solids Specific conductance Sulfate Surfactants Temperature Trace elements Turbidity	Alkalinity BOD Cations/Anions DO Flow Hardness Herbicides Hydrocarbons Oil & Grease pH Phenols Specific conductance Surfactants Temperature Total dissolved solids Total suspended solids Trace elements Turbidity

Table 4. Association between water-quality and quantity issues and hydrologic characteristics within NCPN parks.

TYPE OF WATER RESOURCE	WATER-RESOURCE ISSUES						
	HUMAN CONTACT[1]	RECREATIONAL IMPACT[2]	ADJACENT AND INTERNAL DEVELOPMENT[3]	LIVESTOCK GRAZING[4]	THREATENED OR ENDANGERED SPECIES[5]	INSTREAM STANDARDS[6]	IMPACTS OF ADJACENT PUBLIC LAND[7]
Perennial	BLCA, CANY, CURE, CARE, DINO, ZION	CANY, CARE, CURE, TICA, ZION	ARCH, CANY, CARE, CURE, DINO, GOSP, ZION	BLCA, CANY, CARE, CURE, DINO, ZION	BLCA, CANY, CURE, DINO, ZION	BLCA, CURE, CARE, DINO, ZION	ARCH BRCA, CANY, CARE, CURE, DINO, FOBU TICA, ZION
Intermittent and Ephemeral	ARCH, FOBU, NABR	ARCH, BRCA, FOBU, GOSP, NABR	COLM, FOBU	ARCH, FOBU, NABR			COLM
Aquifers	TICA	ARCH, BRCA, CANY, CARE, COLM, DINO, PISP, ZION	BRCA, CARE, ZION				
Seeps, Springs, & Hanging Gardens		ARCH, BRCA, CANY, COLM, CARE, CURE, HOVE, PISP	ARCH, CANY, CEBR, COLM, CARE, CURE, HOVE, NABR, PISP	ARCH, BRCA, CANY, CARE CEBR, HOVE, NABR, PISP			ARCH, CANY, CEBR, COLM, CARE, CURE, HOVE
Tinajas	ARCH, CANY, CARE, ZION	ARCH, CANY, CARE, ZION		CARE			
Wetlands		BRCA		BRCA			BRCA

1 Includes Recreational activities associated with water such as swimming, wading, and obtaining drinking water where there is a concern for transmission of communicable diseases.
2 Includes impacts from recreational activities such as hiking, vehicle use, and human waste disposal.
3 Includes construction of such things as roads and buildings, and disposal of treated wastewater which can occur in or near the park.
4 Includes impacts from livestock grazing inside or outside of the park.
5 Includes impacts that might occur to aquatic or riparian habitats of sensitive, threatened or endangered species.
6 Includes the development of source-specific water quality standards under the anti-degradation provisions of the Clean Water Act.
7 Includes impacts from activities that typically occur on public lands adjacent to the park, such as grazing, mining, off-road vehicle use, recreation and oil and gas development.

Park Acronyms:

ARCH = Arches National Park,
BLCA = Black Canyon of the Gunnison National Park,
BRCA = Bryce Canyon National Park,
CANY = Canyonlands National Park,
CARE = Capitol Reef National Park,
CEBR = Cedar Breaks National Monument,
COLO = Colorado National Monument,
CURE = Curecanti National Recreation Area,
DINO = Dinosaur National Monument,
FOBU = Fossil Butte National Monument,
GOSP = Golden Spike National Historic Site,
HOVE = Hovenweep National Monument,
NABR = Natural Bridges National Monument
PISP = Pipe Spring National Monument,
TICA = Timpanogos Cave National Monument, and
ZION = Zion National Park

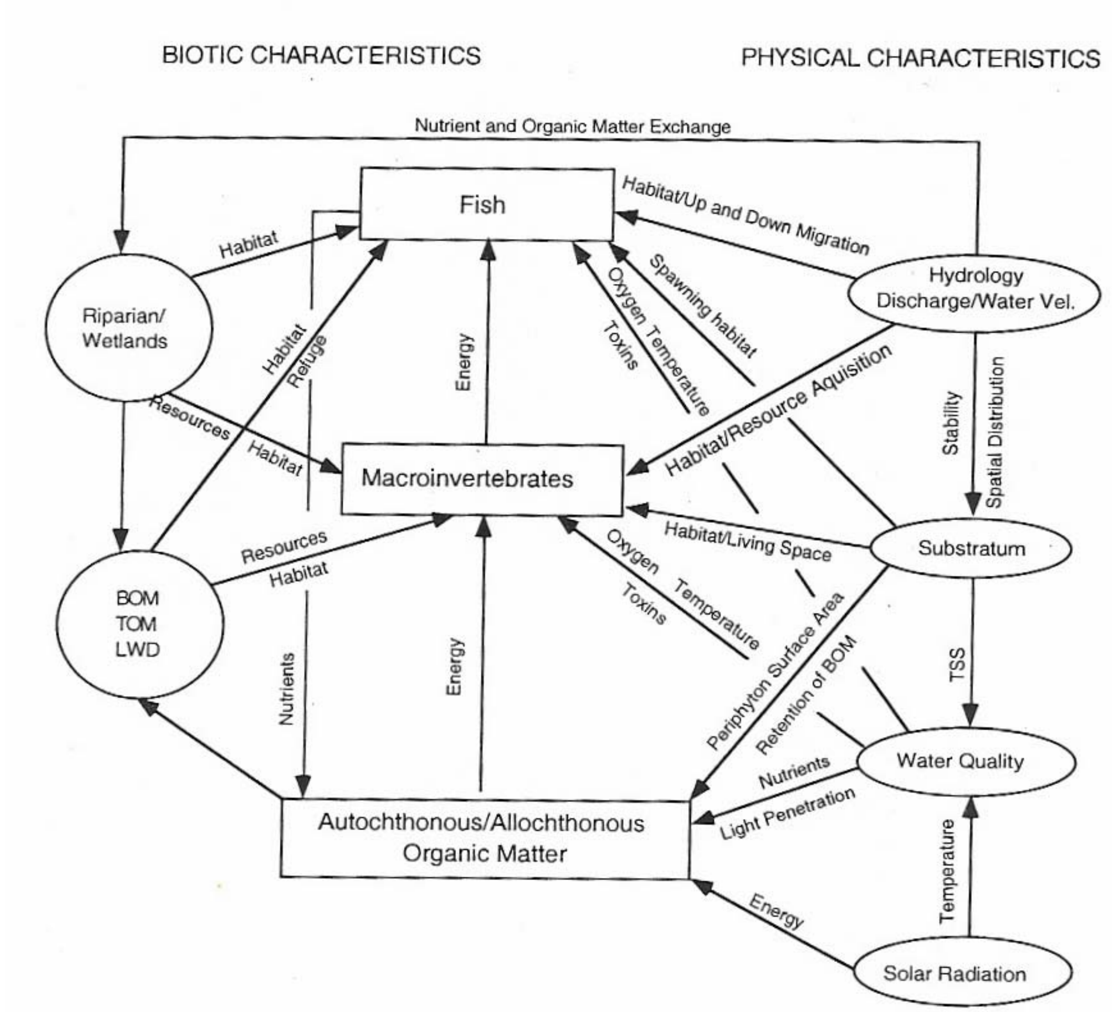

Figure 1. Model of stream ecosystem identifying major biotic and abiotic components. River hydrology serves as a major driver for both water quality and the stream biota. Macroinvertebrates may serve as an excellent indicator of change in river hydrology and water quality (adapted from Davis et al. 2001).